Reduce Boiler Blowdown Water

Prepared for California Energy Commission (CEC)

Prepared By:

Southern California Gas Company
(A Sempra Energy Utility)

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Executive Summary

This calculator tool can be used to estimate annual energy savings and the associated money (US dollars) savings and reductions in CO_2 emissions through the reduction or minimization of boiler blowdown water via appropriate sensors and control for steam drum water quality. Minimizing blowdown rate can substantially reduce energy losses by reducing the hot blow down liquid sent to the sewer. Minimizing blowdown will also reduce makeup water and chemical treatment costs.

As water evaporates in the boiler steam drum, solids present in the feed water are left behind. The suspended solids form sludge or sediments in the boiler, which degrades heat transfer. Dissolved solids promote foaming and carryover of boiler water into the steam. To reduce the levels of suspended and total dissolved solids (TDS) to acceptable limits, water is periodically discharged or blown down from the boiler. Mud or bottom blowdown is usually a manual procedure done for a few seconds on intervals of several hours and is designed to remove suspended solids that settle out of the boiler water and form a heavy sludge. Surface or skimming blowdown is designed to remove the dissolved solids that concentrate near the liquid surface. Surface blowdown is often a continuous process.

Insufficient blowdown may lead to carryover of boiler water into the steam, or the formation of deposits. Excessive blowdown will waste energy, water, and chemicals. The optimum blowdown rate is determined by various factors including the boiler type, operating pressure, water treatment, and quality of makeup water. Blowdown rates typically range from 4% to 8% of boiler feed water flow rate, but can be as high as 10% when makeup water has a high solids content.

This tool allows the user to calculate energy saving associated with reducing or minimizing boiler blow down water.

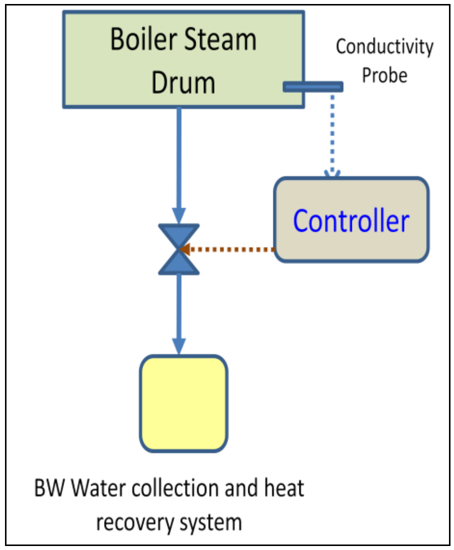

Exhibit 1: Typical boiler blowdown control system

The calculator estimates the annual energy savings in terms of million British Thermal Units (MMBtu/year) andestimates the energy cost savings using the cost of fuel for the industrial application and number of operating hours per year. This calculator also gives the reduction of CO_2 emissions that result from the combustion of natural gas.

The user is required to give data for several operating parameters that can be measured or estimated during the normal operating conditions or from available records. Measurements used for the calculations should be performed during typical or average operating conditions.

The primary objective of this calculator is to promote energy savings in industrial heating operations, and to allow users to calculate potential savings. The calculator's results should be considered preliminary and a starting point for more detailed technical and economic analysis. The results are to be used as a basis for a go / no go decision for further analysis. The accuracy of the calculator's results is expected to be within plus or minus 5 percent.

Note to the user of this calculator tool

Use of this tool requires knowledge and operation of boilers. The user is referred to several training programs and references quoted at the end of his document for further information on the available resources for getting trainings that would provide additional knowledge for the subject matters discussed in this document.

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LIST OF EXHIBITS

1. Description of the subject area

This technical guide describes a calculator tool that will allow a user to estimate annual energy (fuel) savings, reductions in CO_2 emissions, reduction in water use, and energy cost savings ($/year) by installing monitoring and control technologies to reduce the amount of boiler blow down water. Controlled release of blow down water to replace continuous blow down can result in substantial savings in energy use for the boiler and in use of boiler make up water, resulting in reduction in boiler operating cost.

Steam generation in boiler requires feed water that is often composed of a mixture of returned condensate and treated make up water. Even with significant water treatment, a small amount of dissolved solids (TDS) are contained in the feed water. These TDSs can accumulate within boiler when water is evaporated to generate steam. To reduce the amount of dissolved solids in the boiler and prevent deposits from forming, it is common practice to discharge or release a small amount of water from the steam drum.. Many boilers allow for a continuous water discharge of water. The rate of water blowdown can range from less than 1% when extremely high-quality feed water is available to greater than 20% in a system with poor-quality feed water. This water contains substantial percentage of total heat input for the boiler. In many cases, the blown down water is sent to the sewer, resulting in waste of energy and water resource.

One of the various methods to reduce energy and water use is to control the blow down rate to maintain a safe level of TDS in the boiler. Using a conductivity sensor attached to the boiler, the TDS can be constantly monitored. A commonly used blowdown control system is shown in Exhibit 2. For additional information, see Reference 1.

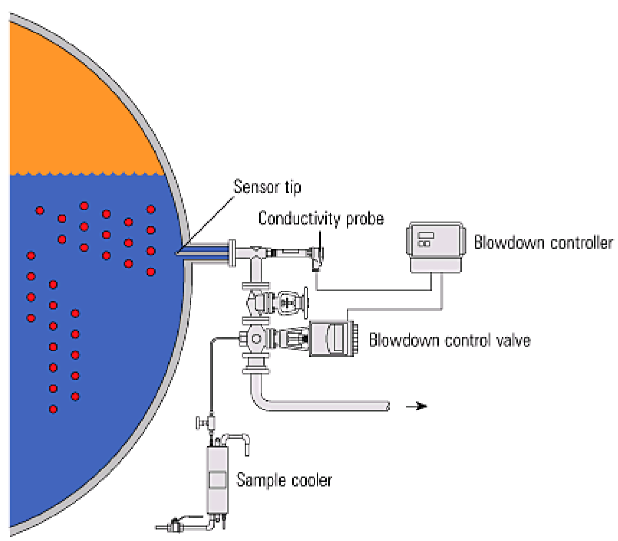

Exhibit 2: Components of a boiler blowdown or water quality control system
(Courtesy – Spirax Sarco)

In a blowdown control system (similar to Exhibit 2), a conductivity probe is used to monitor conductivity of water inside the boiler drum. The signal from this probe is used to control the amount of blow down water discharged from the drum to maintain the desired TDS level within the boiler. Information on the allowable or desired amount of TDS should be obtained for the boiler supplier, water treatment system supplier, and/or steam industry experts available at several reputable companies. Once again, refer to Reference 1 for information from one of the well known suppliers.

A controlled rate of blow down water reduces boiler water discharge and offers associated savings. This calculator is most effective when the blow down rate (current and expected) and boiler operating conditions are known.

This calculator estimates the annual expected energy savings in terms of million British thermal units (MMBtu/year) and estimates the energy cost reduction using the given cost of fuel for the oven and the number of operating hours per year. This calculator also gives the reduction in water use and CO_2 emissions that result from application of the suggested energy saving measure.

A brief summary of the important parameters follows:

Steam evaporation rate: The rate of steam generation for the boiler or boiler system. Steam flow rates can be determined using steam flow meters or other sources such as boiler steam capacity and boiler loading.

Percent Reduction in boiler blow down rate – An estimated value based on current and expected values of boiler blow down rate. This value can range anywhere from 1% to 8% depending on current blow down rate, water quality etc. If the boiler blowdown rate is unknown, it is suggested that a "sensitivity" analysis and/or contact a reputable control equipment supplier. You may start with the water chemical supplier or the information given in Reference 1.

Boiler operating conditions – Operating conditions of a typical boiler system include such items as steam generation pressure (in psig), feed water temperature (^{O}F), and makeup water temperature (^{O}F). This information can be obtained from the boiler records.

Boiler efficiency (%) – This value should be obtained from the boiler supplier, operating manual, flue gas analysis, or estimate based on current operating conditions. Depending on the boiler design and system operating conditions, this value can vary from 65% to 85% for most commonly used boilers.

Number of operating hours (hours/year) – This is the number of hours for which the equipment is operated. This should be based on a recent 12-month period.

Cost of fuel – The average fuel cost ($/MM Btu) based on the historical consumption and, if possible, future projected cost based on contracts with the energy supplier.

2. Impact of boiler blow down water reduction on energy savings and CO2 emissions

This calculator allows a user to estimate energy (fuel) savings that can be achieved by controlling and reducing the rate of boiler water blow down. The fuel savings from implementing this measure results in reduction of CO_2 emissions. All commonly used fossil fuels such as natural gas (the most commonly used industrial fuel for California industries) results in the formation of CO_2. The reduction in CO_2 emissions is directly proportional to the reduction in natural gas use. Additionally, a reduction in the amount of blowdown from a boiler will result in reduction of water use and related cost savings.

The energy savings from a blowdown reduction project can vary from 0.5% for well run boilers to 1.5% in case where the water quality is not maintained properly. Annual energy cost savings depends on the cost of energy, expressed as US dollars per MM Btu. The approximate value of savings can be estimated by using this calculator.

The CO_2 savings are directly related to energy savings. According to U.S. Environmental Protection Agency (EPA) estimates (Reference 5), the combustion of natural gas used in USA produces 116.39 lbs. of CO_2 per MM Btu heat input. For the sake of simplicity, most calculations use 117 lbs. CO_2 emission per MM Btu heat input from natural gas. If the natural gas composition is available for a facility, it is advisable to carry out detailed combustion calculations to estimate a more accurate value for the CO_2 produced by the combustion of natural gas. Reduction in CO_2 emissions is calculated by using the value of reduction in energy (fuel) used for the furnace.

Water savings incurred are due to reduction in the boiler system feed water requirements. This saving can result in savings in cost of water and cost of chemicals required to treat this water as well as some savings in water pumping cost (usually too small to be considered for this calculator).

3. Discussion on the technical approach and the calculations

Control of boiler blow down rate will result in energy savings while maintaining the desired steam quality for the boiler. The annual energy savings (MM Btu/year) is the difference between the annual energy use by the baseline system and the annual energy use by the boiler after the implementation of this efficiency measure. In all cases involving boiler blow down reduction an essential step is to measure the blow down water quantity before and after implementation of the measure. The current value can be obtained by knowing steam production and boiler feed water entering the boiler. In most cases, these values should be available from current instrumentation or good estimate.

The main objective for this measure is to maintain steam quality while reducing energy and water use. With uncontrolled or manual control of blowdown, it is difficult to determine the concentration of dissolved solids in the boiler water and the optimal blowdown rate. Without measurements, operators do not know when to blow down the boiler or for how long. Likewise, using a fixed rate of blowdown does not take into account changes in makeup and feed water conditions, or variations in steam demand or condensate return.

An automatically controlled blowdown system optimizes blowdown rates by regulating the volume of water discharged in relation to the concentration of dissolved solids present within the boiler. Automatic blowdown control systems maintain water chemistry within acceptable limits, while minimizing blowdown and reducing energy losses.

There are several methods available to determine the appropriate amount of boiler blow down, however the most commonly used method utilizes a conductivity probe to measure conductivity of the boiler water and use that value to determine level of blow down required. Automatic blowdown-control systems use high- or low-pressure probes are used to measure conductivity. The conductivity probes provide feedback to a blowdown controller that compares the measured conductivity with a set-point value and transmits an output signal that drives a modulating blowdown release valve. Conductivity is a measure of the electrical current carried by positive and negative ions when a voltage is applied across electrodes in a water sample. Conductivity increases when the dissolved ion concentrations increase. The measured current is directly proportional to the specific conductivity of the fluid. Total dissolved solids, silica, chloride concentrations, and/or alkalinity contribute to conductivity measurements. These chemical species are reliable indicators of salts and other contaminants in the boiler water.

Boilers without blowdown or boilers with high blowdown rates offer significant energy savings potential. The optimum blowdown rate is determined by a number of factors, including boiler type, operating pressure, water treatment, and makeup-water quality. Energy savings also depend upon the quantity of steam condensate returned to the boiler. With a low percentage of condensate return, more makeup water is required and additional blowdown must occur. Boiler blowdown rates often range from 1% to 8% of the feed water flow rate, but they can be as high as 20% to maintain boiler water within conductivity limits when the makeup water has a high solids content.

Energy savings resulting from boiler blow down control (and associated cost reductions) is due to a reduction in the water flow from the boiler drum. The water that is blown down is at the steam generation pressure and corresponding saturation temperature. The amount of heat content depends on steam pressure since it is considered to be at saturation temperature. The actual amount of energy reduction is the difference in heat content between the blow down water (Btu/lb–hr.) and the feed water (Btu/lb–hr.) as it enters the boiler and amount of water (lbs/hr) reduction.

Heat content of water can be obtained from steam table that is included as Appendix 1 and can also be obtained using a link in the calculator tool.

The amount of water reduction is calculated by knowing the current steam production and blow down rate.

Reduction in heat required for the reduction in blow down water is calculated as follows.

Where

M_{steam} = Steam production rate (average) - Lbs. per day

% B_{wc} = Boiler blow down in terms of % of steam production

M_{fwc} = Current rate of boiler blow down - Lbs per day

ΔM_{bw} = Reduction in blow down water lbs/day

$\Delta \% B_{wc}$ = Percent reduction in blow down water.

ΔM_{bw} = Reduction in blow down water flow rate (Lbs. /year) Δ%Bwc*Mfwc

ΔH_{bw} = Reduction in heat for blow down water (Million [MM] Btu/day)

H_{bw} = This is heat content of water at steam pressure – Btu/lb

H_{fw} = Heat content of feed water entering the boiler – Btu/lb.

η_b = Boiler efficiency in %

The energy savings and associated CO_2 emission reduction are calculated for natural gas. Boiler water related savings are calculated to account for cost of water and chemicals etc. used for water treatment.

4. Instruction on use of the calculator

The following list summarizes the user inputs that are required. The user should collect this information before using this calculator tool.

- Company name, plant location and address
- Customer name and contact information
- Heating equipment description (where the energy-saving measure is applied)
- Equipment type (furnace, oven, kiln, heater, boiler)
- Equipment use (e.g., textile drying, aluminum melting, food processing)

Note that some of this information may be optional for the web-based calculators due to users' concerns about privacy.

The following input data is required from the user.

- Steam generation or evaporation (lbs/day)
- Current boiler blow down rate (% of steam production)
- % Reduction in Boiler blow down rate (% of steam production)
- Boiler Pressure (psig)
- Makeup water temperature (°F)
- Enthalpy of blow down water (Btu/lb)*
- Enthalpy of makeup water at temperature (Btu/lb)*

- Boiler efficiency (%)
- No. of operating days per year (days/year)
- Cost of fuel ($/MM Btu)
- Cost of water and chemicals (for makeup water) - ($/gallon of water)

*** Note:** Obtain these values from Steam Tables.

The calculator gives following results.

- Current value of blowdown (lb/day)
- Feed water (steam + blowdown) lb/day
- Reduction in blow down water (lb/day)
- Net heat addition in blow down water (Btu/lb)
- Gross heat required for the water (Btu/lb)
- Gross heat required for the water (Btu/lb)
- Energy savings (MM Btu/year)
- Annual fuel cost savings ($ per year)
- Total cost savings ($/year)
- CO_2 savings (Tons/year)
- Water savings (Gallons/year)

Note that the CO_2 savings are based on natural gas as the fuel for the heating equipment. A correction factor must be applied if any other fuel is used.

This calculator requires the following input parameters describing the heating process in order to estimate the savings. Exhibit 3 shows the user information screen and Exhibit 4 shows the calculator screen.

The first section requires information about the user, equipment, and process.

Line 1 – <u>Name of the company</u>.

Line 2 – <u>Name or known designation such as "main plant" or "secondary plant" if applicable</u>.

Line 3 – <u>Plant address</u>.

Line 4 – <u>Contact name for the plant –</u> This individual is main contact and is responsible for collecting and providing the required information.

Line 5 – <u>Address for the contact person</u>.

Line 6 – <u>Contact phone number and e-mail to be used for all future communications</u>.

Line 7 – <u>Date when the calculations are carried out</u>.

Reduce Boiler Blowdown Water						
1	Company name	ABC Corporation				
2	Plant name or designation	LA Plant				
3	Plant address	12345 Main Street, Gabriel, CA 90878				
4	Contact name	Bob Smith				
5	Contact address	54321 First Street, North Warren, CA 90878				
6	Contact phone number and e-mail	Phone:	916-756-9923	E-mail:	b.smith@abccorp.com	
7	Date (format mm/date/year)	May 12, 2010				
Heating equipment description (where the energy saving measure is applied)						
8	Equipment type (e.g. furnace, oven, kiln, heater, boiler)		Drying oven			
9	Equipment use (e.g., textile drying, aluminum melting)		Metal coating			
10	Other comments if any	The oven is designed with a computer control system.				

Exhibit 3: Required information for the calculator user

Line 8 – Type of heating equipment – This can be an oven, furnace, boiler, heater, etc. This is the heating equipment where data is collected and the given energy saving measure is to be applied.

Line 9 – Process or function for which the heating equipment is used – This can be name of the process such as drying, melting, water heating, etc.

Line 10 – Any additional information that can be useful in application of the results.

The second section of the calculator is used for collecting the necessary data and reporting the estimated savings.

Exhibit 4 shows the required data for the calculator. The calculator cells are color coded. The white color cells are used for data input by the user while the colored (yellow and light blue or green) cells are protected and give results of the calculations. The user is not allowed change numbers shown in the colored cells.

Line 11 – Steam production (lbs/day) – Give value of average steam generation or evaporation rate in terms of lbs. of steam per day. This should represent average value for operating days over a year or representative period.

Line 12 – % Reduction in boiler blow down rate – This is an estimated or calculated value of reduction expressed as % of current steam production. Depending on the current practices and water quality, this number could vary from 1% to 5%. This information can be obtained from boiler supplier, water treatment equipment supplier, steam system suppliers, or local sales representatives who supply steam system components. If a good number is not available then carry out several calculations using different values starting from 1% and increasing by an incremental value of ½ % or 1% to get values of possible savings.

Reduction of Blow Down Water		
11	Steam production (lb./day)	100,000
12	% Reduction in Boiler blow down rate (% of steam production)	2%
14	Feedwater (steam + blowdown) lb./day	102,041
15	Boiler Pressure (psig)	600
16	Feedwater Temperature (°F)	240
17	Reduction in blow down water (lb./day)	2,041
18	Enthalpy in blow down water at boiler pressure, h_f (Btu/lb.) * from steam table	475
19	Make up water temperature (°F)	60
20	Enthalpy in make up water at temperature, h_f (Btu/lb.)* from steam table	28
21	Net heat addition in blow down water (Btu/lb.)	447
22	Boiler efficiency	75%
23	Gross heat required for the water (Btu/lb.)	596.0
24	Total heat savings for the boiler (MM Btu/day)	1.22
25	No. of operating days per year (days/year)	360
26	**Energy savings (MM Btu/year)**	**438**
27	Cost of fuel ($/MM Btu)	$ 7.00
28	Annual fuel cost savings ($ per year)	$ 3,065
29	Cost of water and chemicals for make up water ($/gallon of water)	$ 0.0050
30	**Total cost savings ($/year)**	**$ 3,506**
31	Cost of implementation	$ 500
32	**Payback period (months)**	**1.71**
33	**CO2 savings (Tons/year)**	**26**
34	**Water savings (Gallons/year)**	**88,093**

Exhibit 4: Example of calculator inputs and results

Line 14 – <u>Feed water (steam + blowdown) lb/day</u> – This is a calculated valuebased on data given above.

Line 15 – <u>Boiler pressure (psig).</u> Use steam pressure in psig as it is discharged from the boiler. In most cases this value should be available on a panel or gage in boiler control room.

Line 16 – <u>Feedwater temperature (°F)</u> – The current temperature of feedwater water entering the boiler.

Line 17 – <u>Reduction in blow down water (lb/day)</u> – This is a calculated value based on the data given above.

Line 18 – Enthalpy of blow down water (Btu/lb) – This represents heat content or enthalpy of blow down water. It is obtained from a steam table given as a link within the calculator. The steam table is also given as Appendix 1 for the Technical Guide. Make sure to use absolute pressure for looking up values (absolute pressure [psia] = psig + 14.7) while looking up this value in a steam table.

Line 19 – Makeup water temperature (°F) – The current temperature of makeup water entering the steam system. This water is added to the boiler system to compensate for loss of water that is discharged as makeup water.

Line 20 – Enthalpy of makeup water at temperature (Btu/lb.) – This represents heat content (enthalpy) of makeup water as it enters the steam system. It is obtained from a steam table given as a link within the calculator. The steam table is also given as Appendix 1 for the Technical Guide. Make sure to use absolute pressure for looking up values (absolute pressure [psia] = psig + 14.7) while looking up this value in a steam table.

Line 21 – Net heat addition in blow down water (Btu/lb) – This is a calculated value based on the data given above. It is the difference between Line 19 and Line 20 above.

Line 22 – Boiler efficiency (%) – Boiler efficiency can be calculated by using values of energy input or fuel used in the boiler and total heat content of steam produced in the boiler. If it is not possible to get this value, contact the boiler supplier, review the boiler operating manual, or use name plate data. If none of this is available then you may use nominal value of 70% for a boiler without an economizer and 75% for a boiler with an economizer. Note that this is an approximate value and should not be considered as final and accurate.

Line 23 – Gross heat required for the water (Btu/lb) – This is a calculated value based on data given in lines 21 and 22 above.

Line 24 – Total heat savings for the boiler (MM Btu/day) – This a calculated value based on data given in lines 23 and 18 above.

Line 25 – No. of operating days per year (days/year) – Give number of operating days per year for the boiler.

Line 26 - Energy savings (MM Btu/year) – This is a calculated value based on data given in lines 24 and 25 above.

Line 27 – Cost of fuel ($/MM Btu) – The user gives cost of fuel expressed in terms of $/MM Btu. The cost should include all charges related to use of fuel at "the burner tip". This value can be obtained directly from monthly or annual gas bills. It is often stated as a line item on the bill. If the bill does not specifically mention the gas cost then it is necessary to calculate average cost of fuel by using values of total fuel cost and annual fuel used.

If necessary, contact the fuel (natural gas) supplier or distributor for more information.

Line 28 – Annual fuel cost savings ($/year) – This is a calculated value based on data given in lines 26 and 27 above.

Line 29 – Cost of water and chemicals for makeup water ($/gallon of water) – Give cost of water and chemicals used for water treatment plus any other water treatment related cost to allow calculations for related cost savings.

Line 30 - Total cost savings ($/year) – This is a calculated value based on data and calculations in lines 28 and 29 above.

Line 31 - Cost of implementation ($) – The cost to implement blowdown reduction systems.

Line 32 – Payback period (months) – The amount of time required for the payback of initial cost.

Line 31 - Reduction in CO_2 emissions (tons/year) – These savings are calculated based on annual fuel savings, assuming the fuel used is natural gas. The savings are in Short (US) tons, not in Metric tons.

Line 32 - Water savings (Gallons/year) – This is a calculated value based on data given in lines 13 and 25 above.

5. References and Resources

1. Web site: http://www.spiraxsarco.com/resources/steam-engineering-tutorials/the-boiler-house/heat-recovery-from-boiler-blowdown.asp
2. *Unit Conversions, Emission Factors, and Other Reference Data*, published by the U.S. EPA, November 2004. Available online at http://www.epa.gov/cpd/pdf/brochure.pdf
3. *North American Combustion Handbook*, Third Edition, 1986. Published by North American Mfg. Company, Cleveland, OH.

   4. Improving Process Heating System Performance: A Sourcebook for Industry, U.S. Department of Energy. Available online at

   http://www1.eere.energy.gov/industry/bestpractices/pdfs/steamsourcebook.pdf

5. *Tip sheets and Technical Briefs*, published by The U.S. Department of Energy. Available online at

   http://www1.eere.energy.gov/industry/utilities/steam_tools.html

6. Training opportunities for process heating technology

- The U. S. Department of Energy (DOE), Energy Efficiency and Renewable Energy (EERE) Office of Industrial Technologies (ITP) web site. http://www1.eere.energy.gov/industry/
- Sempra Energy – Southern California Gas Company web site. www.socalgas.com
- California Energy Commission web site

  www.energy.ca.gov

Appendix 1

Steam Tables

The following link will allow the user to calculate steam properties

If necessary please copy and paste this link to your Internet browser

http://www.spiraxsarco.com/us/resources/steam-tables.asp

Definition of Steam Properties

- *p – Pressure (psia)*
- *T* - Temperature (deg. F)
- *v* – Specific volume (ft^3/lbm)
- *u* – Internal energy (Btu/lbm)
- *h* – Total enthalpy or heat (Btu/lbm)
- *s* – Entropy (Btu/lb-F)

The saturation temperature is shown with each pressure in red.

Superheated Water (H2O) Table												
deg-F	ft^3/lbm	Btu/lbm	Btu/lbm	Btu/lbm	ft^3/lbm	Btu/lbm	Btu/lbm	Btu/lbm	ft^3/lbm	Btu/lbm	Btu/lbm	Btu/lbm
T	*p* = 1.0 psia (101.70 F)				*p* = 5.0 psia (162.21 F)				*p* = 10.0 psia (193.19 F)			
	v	*u*	*h*	*s*	*v*	*u*	*h*	*s*	*v*	*u*	*h*	*s*
Sat.	333.6	1044.0	1105.8	1.9779	73.53	1063.0	1131.0	1.8441	38.42	1072.2	1143.3	1.7877
200	392.5	1077.5	1150.1	2.0508	78.15	1076.3	1148.6	1.8715	38.85	1074.7	1146.6	1.7927
240	416.4	1091.2	1168.3	2.0775	83.00	1090.3	1167.1	1.8987	41.32	1089.0	1165.5	1.8205
280	440.3	1105.0	1186.5	2.1028	87.83	1104.3	1185.5	1.9244	43.77	1103.3	1184.3	1.8467
320	464.2	1118.9	1204.8	2.1269	92.64	1118.3	1204.0	1.9487	46.20	1117.6	1203.1	1.8714
360	488.1	1132.9	1223.2	2.1500	97.45	1132.4	1222.6	1.9719	48.62	1131.8	1221.8	1.8948
400	511.9	1147.0	1241.8	2.1720	102.24	1146.6	1241.2	1.9941	51.03	1146.1	1240.5	1.9171
440	535.8	1161.2	1260.4	2.1932	107.03	1160.9	1259.9	2.0154	53.44	1160.5	1259.3	1.9385
500	571.5	1182.8	1288.5	2.2235	114.20	1182.5	1288.2	2.0458	57.04	1182.2	1287.7	1.9690
600	631.1	1219.3	1336.1	2.2706	126.15	1219.1	1335.8	2.0930	63.03	1218.9	1335.5	2.0164
700	690.7	1256.7	1384.5	2.3142	138.08	1256.5	1384.3	2.1367	69.01	1256.3	1384.0	2.0601
800	750.3	1294.9	1433.7	2.3550	150.01	1294.7	1433.5	2.1775	74.98	1294.6	1433.3	2.1009
1000	869.5	1373.9	1534.8	2.4294	173.86	1373.9	1534.7	2.2520	86.91	1373.8	1534.6	2.1755
1200	988.6	1456.7	1639.6	2.4967	197.70	1456.6	1639.5	2.3192	98.84	1456.5	1639.4	2.2428
1400	1107.7	1543.1	1748.1	2.5584	221.54	1543.1	1748.1	2.3810	110.76	1543.0	1748.0	2.3045
T	*p* = 14.696 psia (211.99 F)				*p* = 20 psia (227.96 F)				*p* = 40 psia (267.26 F)			
	v	*u*	*h*	*s*	*v*	*u*	*h*	*s*	*v*	*u*	*h*	*s*
Sat.	26.80	1077.6	1150.5	1.7567	20.09	1082.0	1156.4	1.7320	10.501	1092.3	1170.0	1.6767
240	28.00	1087.9	1164.0	1.7764	20.47	1086.5	1162.3	1.7405				
280	29.69	1102.4	1183.1	1.8030	21.73	1101.4	1181.8	1.7676	10.711	1097.3	1176.6	1.6857
320	31.36	1116.8	1202.1	1.8280	22.98	1116.0	1201.0	1.7930	11.360	1112.8	1196.9	1.7124
360	33.02	1131.2	1221.0	1.8516	24.21	1130.6	1220.1	1.8168	11.996	1128.0	1216.8	1.7373
400	34.67	1145.6	1239.9	1.8741	25.43	1145.1	1239.2	1.8395	12.623	1143.0	1236.4	1.7606
440	36.31	1160.1	1258.8	1.8956	26.64	1159.6	1258.2	1.8611	13.243	1157.8	1255.8	1.7828
500	38.77	1181.8	1287.3	1.9263	28.46	1181.5	1286.8	1.8919	14.164	1180.1	1284.9	1.8140
600	42.86	1218.6	1335.2	1.9737	31.47	1218.4	1334.8	1.9395	15.685	1217.3	1333.4	1.8621

T	p = 14.696 psia (211.99 F)				p = 20 psia (227.96 F)				p = 40 psia (267.26 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
700	46.93	1256.1	1383.8	2.0175	34.47	1255.9	1383.5	1.9834	17.196	1255.1	1382.4	1.9063
800	51.00	1294.4	1433.1	2.0584	37.46	1294.3	1432.9	2.0243	18.701	1293.7	1432.1	1.9474
1000	59.13	1373.7	1534.5	2.1330	43.44	1373.5	1534.3	2.0989	21.70	1373.1	1533.8	2.0223
1200	67.25	1456.5	1639.3	2.2003	49.41	1456.4	1639.2	2.1663	24.69	1456.1	1638.9	2.0897
1400	75.36	1543.0	1747.9	2.2621	55.37	1542.9	1747.9	2.2281	27.68	1542.7	1747.6	2.1515
1600	83.47	1633.2	1860.2	2.3194	61.33	1633.2	1860.1	2.2854	30.66	1633.0	1859.9	2.2089

T	p = 60 psia (292.73 F)				p = 80 psia (312.07 F)				p = 100 psia (327.86 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	7.177	1098.3	1178.0	1.6444	5.474	1102.6	1183.6	1.6214	4.434	1105.8	1187.8	1.6034
320	7.485	1109.5	1192.6	1.6634	5.544	1106.0	1188.0	1.6271				
360	7.924	1125.3	1213.3	1.6893	5.886	1122.5	1209.7	1.6541	4.662	1119.7	1205.9	1.6259
400	8.353	1140.8	1233.5	1.7134	6.217	1138.5	1230.6	1.6790	4.934	1136.2	1227.5	1.6517
440	8.775	1156.0	1253.4	1.7360	6.541	1154.2	1251.0	1.7022	5.199	1152.3	1248.5	1.6755
500	9.399	1178.6	1283.0	1.7678	7.017	1177.2	1281.1	1.7346	5.587	1175.7	1279.1	1.7085
600	10.425	1216.3	1332.1	1.8165	7.794	1215.3	1330.7	1.7838	6.216	1214.2	1329.3	1.7582
700	11.440	1254.4	1381.4	1.8609	8.561	1253.6	1380.3	1.8285	6.834	1252.8	1379.2	1.8033
800	12.448	1293.0	1431.2	1.9022	9.321	1292.4	1430.4	1.8700	7.445	1291.8	1429.6	1.8449
1000	14.454	1372.7	1533.2	1.9773	10.831	1372.3	1532.6	1.9453	8.657	1371.9	1532.1	1.9204
1200	16.452	1455.8	1638.5	2.0448	12.333	1455.5	1638.1	2.0130	9.861	1455.2	1637.7	1.9882
1400	18.445	1542.5	1747.3	2.1067	13.830	1542.3	1747.0	2.0749	11.060	1542.0	1746.7	2.0502
1600	20.44	1632.8	1859.7	2.1641	15.324	1632.6	1859.5	2.1323	12.257	1632.4	1859.3	2.1076
1800	22.43	1726.7	1975.5	2.2179	16.818	1726.5	1975.5	2.1861	13.452	1726.4	1975.3	2.1614
2000	24.41	1824.0	2095.1	2.2685	18.310	1823.9	2094.9	2.2367	14.647	1823.7	2094.8	2.2121

T	p = 120 psia (341.30 F)				p = 140 psia (353.08 F)				p = 160 psia (363.60 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	3.730	1108.3	1191.1	1.5885	3.221	1110.3	1193.8	1.5761	2.836	1112.0	1196.0	1.5651
360	3.844	1116.7	1202.0	1.6021	3.259	1113.5	1198.0	1.5812				
400	4.079	1133.8	1224.4	1.6288	3.466	1131.4	1221.2	1.6088	3.007	1128.8	1217.8	1.5911
450	4.360	1154.3	1251.2	1.6590	3.713	1152.4	1248.6	1.6399	3.228	1150.5	1246.1	1.6230
500	4.633	1174.2	1277.1	1.6868	3.952	1172.7	1275.1	1.6682	3.440	1171.2	1273.0	1.6518
550	4.900	1193.8	1302.6	1.7127	4.184	1192.6	1300.9	1.6944	3.646	1191.3	1299.2	1.6784
600	5.164	1213.2	1327.8	1.7371	4.412	1212.1	1326.4	1.7191	3.848	1211.1	1325.0	1.7034
700	5.682	1252.0	1378.2	1.7825	4.860	1251.2	1377.1	1.7648	4.243	1250.4	1376.0	1.7494
800	6.195	1291.2	1428.7	1.8243	5.301	1290.5	1427.9	1.8068	4.631	1289.9	1427.0	1.7916
1000	7.208	1371.5	1531.5	1.9000	6.173	1371.0	1531.0	1.8827	5.397	1370.6	1530.4	1.8677
1200	8.213	1454.9	1637.3	1.9679	7.036	1454.6	1636.9	1.9507	6.154	1454.3	1636.5	1.9358
1400	9.214	1541.8	1746.4	2.0300	7.895	1541.6	1746.1	2.0129	6.906	1541.4	1745.9	1.9980
1600	10.212	1632.3	1859.0	2.0875	8.752	1632.1	1858.8	2.0704	7.656	1631.9	1858.6	2.0556
1800	11.209	1726.2	1975.1	2.1413	9.607	1726.1	1975.0	2.1242	8.405	1725.9	1974.8	2.1094
2000	12.205	1823.6	2094.6	2.1919	10.461	1823.5	2094.5	2.1749	9.153	1823.3	2094.3	2.1601
T	p = 180 psia (373.13 F)				p = 200 psia (381.86 F)				p = 225 psia (391.87 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	2.533	1113.4	1197.8	1.5553	2.289	1114.6	1199.3	1.5464	2.043	1115.8	1200.8	1.5365
400	2.648	1126.2	1214.4	1.5749	2.361	1123.5	1210.8	1.5600	2.073	1119.9	1206.2	1.5427
450	2.850	1148.5	1243.4	1.6078	2.548	1146.4	1240.7	1.5938	2.245	1143.8	1237.3	1.5779
500	3.042	1169.6	1270.9	1.6372	2.724	1168.0	1268.8	1.6239	2.405	1165.9	1266.1	1.6087
550	3.228	1190.0	1297.5	1.6642	2.893	1188.7	1295.7	1.6512	2.588	1187.0	1293.5	1.6366
600	3.409	1210.0	1323.5	1.6893	3.058	1208.9	1322.1	1.6767	2.707	1207.5	1320.2	1.6624
700	3.763	1249.6	1374.9	1.7357	3.379	1248.8	1373.8	1.7234	2.995	1247.7	1372.4	1.7095
800	4.110	1289.3	1426.2	1.7781	3.693	1288.6	1425.3	1.7660	3.276	1287.8	1424.2	1.7523
900	4.453	1329.4	1477.7	1.8175	4.003	1328.9	1477.1	1.8055	3.553	1328.3	1476.2	1.7920
1000	4.793	1370.2	1529.8	1.8545	4.310	1369.8	1529.3	1.8425	3.827	1369.3	1528.6	1.8292
1200	5.467	1454.0	1636.1	1.9227	4.918	1453.7	1635.7	1.9109	4.369	1453.4	1635.3	1.8977
1400	6.137	1541.2	1745.6	1.9849	5.521	1540.9	1745.3	1.9732	4.906	1540.7	1744.9	1.9600
1600	6.804	1631.7	1858.4	2.0425	6.123	1631.6	1858.2	2.0308	5.441	1631.3	1857.9	2.0177
1800	7.470	1725.8	1974.6	2.0964	6.722	1725.6	1974.4	2.0847	5.975	1725.4	1974.2	2.0716
2000	8.135	1823.2	2094.2	2.1470	7.321	1823.0	2094.0	2.1354	6.507	1822.9	2093.8	2.1223

T	p = 250 psia (401.04 F)				p = 275 psia (409.52 F)				p = 300 psia (417.43 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	1.8448	1116.7	1202.1	1.5274	1.6813	1117.5	1203.1	1.5192	1.5442	1118.2	1203.9	1.5115
450	2.002	1141.1	1233.7	1.5632	1.8026	1138.3	1230.0	1.5495	1.6361	1135.4	1226.2	1.5365
500	2.150	1163.8	1263.3	1.5948	1.9407	1161.7	1260.4	1.5820	1.7662	1159.5	1257.5	1.5701
550	2.290	1185.3	1291.3	1.6233	2.071	1183.6	1289.0	1.6110	1.8878	1181.9	1286.7	1.5997
600	2.426	1206.1	1318.3	1.6494	2.196	1204.7	1316.4	1.6376	2.004	1203.2	1314.5	1.6266
650	2.558	1226.5	1344.9	1.6739	2.317	1225.3	1343.2	1.6623	2.117	1224.1	1341.6	1.6516
700	2.688	1246.7	1371.1	1.6970	2.436	1245.7	1369.7	1.6856	2.227	1244.6	1368.3	1.6751
800	2.943	1287.0	1423.2	1.7401	2.670	1286.2	1422.1	1.7289	2.442	1285.4	1421.0	1.7187
900	3.193	1327.6	1475.3	1.7799	2.898	1327.0	1474.5	1.7689	2.653	1326.3	1473.6	1.7589
1000	3.440	1368.7	1527.9	1.8172	3.124	1368.2	1527.2	1.8064	2.860	1367.7	1526.5	1.7964
1200	3.929	1453.0	1634.8	1.8858	3.570	1452.3	1634.3	1.8751	3.270	1452.2	1633.8	1.8653
1400	4.414	1540.4	1744.6	1.9483	4.011	1540.1	1744.2	1.9376	3.675	1539.8	1743.8	1.9279
1600	4.896	1631.1	1857.6	2.0060	4.450	1630.9	1857.3	1.9954	4.078	1630.7	1857.0	1.9857
1800	5.376	1725.2	1974.0	2.0599	4.887	1725.0	1973.7	2.0493	4.479	1724.9	1973.5	2.0396
2000	5.856	1822.7	2093.6	2.1106	5.323	1822.5	2093.4	2.1000	4.879	1822.3	2093.2	2.0904
T	p – 350 psia (431.82 F)				p – 400 psia (444.70 F)				p – 450 psia (456.39 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	1.3267	1119.0	1204.9	1.4978	1.1620	1119.5	1205.5	1.4856	1.0326	1119.6	1205.6	1.4746
450	1.3733	1129.2	1218.2	1.5125	1.1745	1122.6	1209.6	1.4901				
500	1.4913	1154.9	1251.5	1.5482	1.2843	1150.1	1245.2	1.5282	1.1226	1145.1	1238.5	1.5097
550	1.5998	1178.3	1281.9	1.5790	1.3833	1174.6	1277.0	1.5605	1.2146	1170.7	1271.9	1.5436
600	1.7025	1200.3	1310.6	1.6068	1.4760	1197.3	1306.6	1.5892	1.2996	1194.3	1302.5	1.5732
650	1.8013	1221.6	1338.3	1.6323	1.5645	1219.1	1334.9	1.6153	1.3803	1216.6	1331.5	1.6000
700	1.8975	1242.5	1365.4	1.6562	1.6503	1240.4	1362.5	1.6397	1.4580	1238.2	1359.6	1.6248
800	2.085	1283.8	1418.8	1.7004	1.8163	1282.1	1416.6	1.6844	1.6077	1280.5	1414.4	1.6701
900	2.267	1325.0	1471.8	1.7409	1.9776	1323.7	1470.1	1.7252	1.7524	1322.4	1468.3	1.7113
1000	2.446	1366.6	1525.0	1.7787	2.1360	1365.5	1523.6	1.7632	1.8941	1364.4	1522.2	1.7495
1200	2.799	1451.5	1632.8	1.8478	2.4460	1450.7	1631.8	1.8327	2.1720	1450.0	1630.8	1.8192
1400	3.148	1539.3	1743.1	1.9106	2.7520	1538.7	1742.4	1.8956	2.4440	1538.1	1741.7	1.8823
1600	3.494	1630.2	1856.5	1.9685	3.0550	1629.8	1855.9	1.9535	2.7150	1629.3	1855.4	1.9403
1800	3.838	1724.5	1973.1	2.0225	3.3570	1724.1	1972.6	2.0076	2.9830	1723.7	1972.1	1.9944
2000	4.182	1822.0	2092.8	2.0733	3.6580	1821.6	2092.4	2.0584	3.2510	1821.3	2092.0	2.0453

T	*p* = 500 psia (467.13 F)				*p* = 600 psia (486.33 F)				*p* = 700 psia (503.23 F)			
	v	*u*	*h*	*s*	*v*	*u*	*h*	*s*	*v*	*u*	*h*	*s*
Sat.	0.9283	1119.4	1205.3	1.4645	0.7702	1118.6	1204.1	1.4464	0.6558	1117.0	1202.0	1.4305
500	0.9924	1139.7	1231.5	1.4923	0.7947	1128.0	1216.2	1.4592				
550	1.0792	1166.7	1266.6	1.5279	0.8749	1158.2	1255.4	1.4990	0.7275	1149.0	1243.2	1.4723
600	1.1583	1191.1	1298.3	1.5585	0.9456	1184.5	1289.5	1.5320	0.7929	1177.5	1280.2	1.5081
650	1.2327	1214.0	1328.0	1.5860	1.0109	1208.6	1320.9	1.5609	0.8520	1203.1	1313.4	1.5387
700	1.3040	1236.0	1356.7	1.6112	1.0727	1231.5	1350.6	1.5872	0.9073	1226.9	1344.4	1.5661
800	1.4407	1278.8	1412.1	1.6571	1.1900	1275.4	1407.6	1.6343	1.0109	1272.0	1402.9	1.6145
900	1.5723	1321.0	1466.5	1.6987	1.3021	1318.4	1462.9	1.6766	1.1089	1315.6	1459.3	1.6576
1000	1.7008	1363.3	1520.7	1.7371	1.4108	1361.2	1517.8	1.7155	1.2036	1358.9	1514.9	1.6970
1100	1.8271	1406.0	1575.1	1.7731	1.5173	1404.2	1572.7	1.7519	1.2960	1402.4	1570.2	1.7337
1200	1.9518	1449.2	1629.8	1.8072	1.6222	1447.7	1627.8	1.7861	1.3868	1446.2	1625.8	1.7682
1400	2.1980	1537.6	1741.0	1.8704	1.8289	1536.5	1739.5	1.8497	1.5652	1535.3	1738.1	1.8321
1600	2.4420	1628.9	1854.8	1.9285	2.0330	1628.0	1853.7	1.9080	1.7409	1627.1	1852.6	1.8906
1800	2.6840	1723.3	1971.7	1.9827	2.2360	1722.6	1970.8	1.9622	1.9152	1721.8	1969.9	1.9449
2000	2.9260	1820.9	2091.6	2.0335	2.4380	1820.2	2090.8	2.0131	2.0887	1819.5	2090.1	1.9958

T	*p* = 800 psia (518.36 F)				*p* = 1000 psia (544.75 F)				*p* = 1250 psia (572.56 F)			
	v	*u*	*h*	*s*	*v*	*u*	*h*	*s*	*v*	*u*	*h*	*s*
Sat.	0.5691	1115.0	1199.3	1.4160	0.4459	1109.9	1192.4	1.3903	0.3454	1101.7	1181.6	1.3619
550	0.6154	1138.8	1229.9	1.4469	0.4534	1114.8	1198.7	1.3966				
600	0.6776	1170.1	1270.4	1.4861	0.5140	1153.7	1248.8	1.4450	0.3786	1129.0	1216.6	1.3954
650	0.7324	1197.2	1305.6	1.5186	0.5637	1184.7	1289.1	1.4822	0.4267	1167.2	1266.0	1.4410
700	0.7829	1222.1	1338.0	1.5471	0.6080	1212.0	1324.6	1.5135	0.4670	1198.4	1306.4	1.4767
750	0.8306	1245.7	1368.6	1.5730	0.6490	1237.2	1357.3	1.5412	0.5030	1226.1	1342.4	1.5070
800	0.8764	1268.5	1398.2	1.5969	0.6878	1261.2	1388.5	1.5664	0.5364	1251.8	1375.8	1.5341
900	0.9640	1312.9	1455.6	1.6408	0.7610	1307.3	1448.1	1.6120	0.5984	1300.0	1438.4	1.5820
1000	1.0482	1356.7	1511.9	1.6807	0.8306	1352.2	1505.9	1.6530	0.6563	1346.4	1498.2	1.6244
1100	1.1300	1400.5	1567.8	1.7178	0.8976	1396.8	1562.9	1.6908	0.7116	1392.0	1556.6	1.6631
1200	1.2102	1444.6	1623.8	1.7526	0.9630	1441.5	1619.7	1.7261	0.7652	1437.5	1614.5	1.6991
1400	1.3674	1534.2	1736.6	1.8167	1.0905	1531.9	1733.7	1.7909	0.8689	1529.0	1730.0	1.7648
1600	1.5218	1626.2	1851.5	1.8754	1.2152	1624.4	1849.3	1.8499	0.9699	1622.2	1846.5	1.8243
1800	1.6749	1721.0	1969.0	1.9298	1.3384	1719.5	1967.2	1.9046	1.0693	1717.6	1965.0	1.8791
2000	1.8271	1818.8	2089.3	1.9808	1.4608	1817.4	2087.7	1.9557	1.1678	1815.7	2085.8	1.9304

T	p = 1500 psia (596.39 F)				p = 1750 psia (617.31 F)				p = 2000 psia (636.00 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat	0.2769	1091.8	1168.7	1.3359	0.2268	1080.2	1153.7	1.3109	0.18813	1066.6	1136.3	1.2861
600	0.2816	1096.6	1174.8	1.3416								
650	0.3329	1147.0	1239.4	1.4012	0.2627	1122.5	1207.6	1.3603	0.2057	1091.1	1167.2	1.3141
700	0.3716	1183.4	1286.6	1.4429	0.3022	1166.7	1264.6	1.4106	0.2487	1147.7	1239.8	1.3782
750	0.4049	1214.1	1326.5	1.4767	0.3341	1201.3	1309.5	1.4485	0.2803	1187.3	1291.1	1.4216
800	0.4350	1241.8	1362.5	1.5058	0.3622	1231.3	1348.6	1.4802	0.3071	1220.1	1333.8	1.4562
850	0.4631	1267.7	1396.2	1.5320	0.3878	1258.8	1384.4	1.5081	0.3312	1249.5	1372.0	1.4860
900	0.4897	1292.5	1428.5	1.5562	0.4119	1284.8	1418.2	1.5334	0.3534	1276.8	1407.6	1.5126
1000	0.5400	1340.4	1490.3	1.6001	0.4569	1334.3	1482.3	1.5789	0.3945	1328.1	1474.1	1.5598
1100	0.5876	1387.2	1550.3	1.6399	0.4990	1382.2	1543.8	1.6197	0.4325	1377.2	1537.2	1.6017
1200	0.6334	1433.5	1609.3	1.6765	0.5392	1429.4	1604.0	1.6571	0.4685	1425.2	1598.6	1.6398
1400	0.7213	1526.1	1726.3	1.7431	0.6158	1523.1	1722.6	1.7245	0.5368	1520.2	1718.8	1.7082
1600	0.8064	1619.9	1843.7	1.8031	0.6896	1617.6	1841.0	1.7850	0.6020	1615.4	1838.2	1.7692
1800	0.8899	1715.7	1962.7	1.8582	0.7617	1713.9	1960.5	1.8404	0.6656	1712.0	1958.3	1.8249
2000	0.9725	1814.0	2083.9	1.9096	0.8330	1812.3	2082.0	1.8919	0.7284	1810.6	2080.2	1.8765

T	p = 2500 psia (668.31 F)				p = 3000 psia (695.52 F)				p = 3500 psia			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat	0.13059	1031.0	1091.4	1.2327	0.08404	968.8	1015.5	1.1575				
650									0.02491	663.5	679.7	0.8630
700	0.16839	1098.7	1176.6	1.3073	0.09771	1003.9	1058.1	1.1944	0.03058	759.5	779.3	0.9506
750	0.2030	1155.2	1249.1	1.3686	0.14831	1114.7	1197.1	1.3122	0.10460	1058.4	1126.1	1.2440
800	0.2291	1195.7	1301.7	1.4112	0.17572	1167.6	1265.2	1.3675	0.13626	1134.7	1223.0	1.3226
850	0.2513	1229.5	1345.8	1.4456	0.19731	1207.7	1317.2	1.4080	0.15818	1183.4	1285.9	1.3716
900	0.2712	1259.5	1385.4	1.4752	0.2160	1241.8	1361.7	1.4414	0.17625	1222.4	1336.5	1.4096
950	0.2896	1288.2	1422.2	1.5018	0.2328	1272.7	1402.0	1.4705	0.19214	1256.4	1380.8	1.4416
1000	0.3069	1315.2	1457.2	1.5262	0.2485	1301.7	1439.6	1.4967	0.2066	1287.6	1421.4	1.4699
1100	0.3393	1366.8	1523.8	1.5704	0.2772	1356.2	1510.1	1.5434	0.2328	1345.2	1496.0	1.5193
1200	0.3696	1416.7	1587.7	1.6101	0.3036	1408.0	1576.6	1.5848	0.2566	1399.2	1565.3	1.5624
1400	0.4261	1514.2	1711.3	1.6804	0.3524	1508.1	1703.7	1.6571	0.2997	1501.9	1696.1	1.6368
1600	0.4795	1610.2	1832.6	1.7424	0.3978	1606.3	1827.1	1.7201	0.3395	1601.7	1821.6	1.7010
1800	0.5312	1708.2	1954.0	1.7986	0.4416	1704.5	1949.6	1.7769	0.3776	1700.8	1945.4	1.7583
2000	0.5820	1807.2	2076.4	1.8506	1.4844	1803.9	2072.8	1.8291	0.4147	1800.6	2069.2	1.8108

T	p = 4000 psia				p = 5000 psia				p = 6000 psia			
	v	u	h	s	v	u	h	s	v	u	h	s
650	0.02447	657.7	675.8	0.8574	0.02377	648.0	670.0	0.8482	0.01222	640.0	665.8	0.8405
700	0.02867	742.1	763.4	0.9345	0.02676	721.8	746.6	0.9156	0.02563	708.1	736.5	0.9028
750	0.06331	960.7	1007.5	1.1395	0.03364	821.4	852.6	1.0049	0.02978	788.6	821.7	0.9746
800	0.10522	1095.0	1172.9	1.2740	0.05932	987.2	1042.1	1.1583	0.03942	896.9	940.7	1.0708
850	0.12833	1156.5	1251.5	1.3352	0.08556	1092.7	1171.9	1.2596	0.05818	1018.8	1083.4	1.1820
900	0.14622	1201.5	1309.7	1.3789	0.10385	1155.1	1251.1	1.3190	0.07588	1102.9	1187.2	1.2599
950	0.16151	1239.2	1358.8	1.4144	0.11853	1202.2	1311.9	1.3629	0.09008	1162.0	1262.0	1.3140
1000	0.17520	1272.9	1402.6	1.4449	0.13120	1242.0	1363.4	1.3988	0.10207	1209.1	1322.4	1.3561
1100	0.19954	1333.9	1481.6	1.4973	0.15302	1310.6	1452.2	1.4577	0.12218	1286.4	1422.1	1.4222
1200	0.2213	1390.1	1553.9	1.5423	0.17199	1371.6	1530.8	1.5066	0.13927	1352.7	1507.3	1.4752
1300	0.2414	1443.7	1622.4	1.5823	0.18918	1428.6	1603.7	1.5493	0.15453	1413.3	1584.9	1.5206
1400	0.2603	1495.7	1688.4	1.6188	0.20517	1483.2	1673.0	1.5876	0.16854	1470.5	1657.6	1.5608
1600	0.2959	1597.1	1816.1	1.6841	0.2348	1587.9	1805.2	1.6551	0.19420	1578.7	1794.3	1.6307
1800	0.3296	1697.1	1941.1	1.7420	0.2626	1689.8	1932.7	1.7142	0.21801	1682.4	1924.5	1.6910
2000	0.3625	1797.3	2065.6	1.7948	0.2895	1790.8	2058.6	1.7676	0.24087	1784.3	2051.7	1.7450